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FEDERAL COMMUNICATIONS COMMISSION
OFFICE OF THE SECRETARY

August 13, 1992

RM 8092

Our File No.
1049-101-60

Ms. Donna R. Searcy, Secretary
Federal Communications Commission
1919 M Street N.W.
Washington, D.C. 20554

Re: Request of Radian Corporation for the Allocation of Two MHz in the 914-916 MHz Band for the Co-Secondary Use of Wind Profiler Radar Systems

Dear Ms. Searcy:

Enclosed herewith please find the original and four copies of Radian Corporation's Petition for Rulemaking, as referenced above, with a separate reference appendix.

Should further information concerning the referenced matter be required, please communicate directly with this office.

Very truly yours,

Susan H. Rosenau

Susan H. Rosenau

Enclosures

cc (w/enclosures): K. Russell Peterman

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AUG 13 1992

FEDERAL COMMUNICATIONS COMMISSION
OFFICE OF THE SECRETARY

Before the
FEDERAL COMMUNICATIONS COMMISSION
Washington, D.C. 20554

In the Matter of	)	
	)	
RADIAN CORPORATION	)	
	)	RM 8012
Request for the Allocation of	)	
Two MHz in the 914-916 MHz	)	
Band for the Co-Secondary Use	)	
of Wind Profiler Radar Systems	)	

To: The Commission

PETITION FOR RULEMAKING

Pursuant to Sections 157 and 303(g) of the Communications Act of 1934 and Section 1.401 of the Commission's Rules, Radian Corporation ("Radian") hereby requests that the Commission issue a Notice of Proposed Rulemaking in order to allocate two MHz in the 914-916 MHz band for the co-secondary use of Wind Profiler Radar Systems ("Wind Profilers").1/ If granted an appropriate allocation, Wind Profilers will provide an accurate and economical method for continuous measurement of wind and temperature with great potential usefulness to meteorology, aviation safety and efficiency, and environmental monitoring, with little or no harmful interference to existing primary and other secondary users of the 914-916 MHz band.

Introduction

Radian is a scientific research and consulting firm with its principal place of business in Austin, Texas. In conjunction with the United States National Oceanic and

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1/ In accordance with section 1.403 of the Commission's Rules, Radian shall file a request for Pioneer's Preference in the near future.

Aeronautic Administration ("NOAA"), Radian has developed, enhanced and refined portable wind profiler equipment.

Radian has obtained experimental licenses for operation of Wind Profilers in the 914-916 MHz band at eleven locations in the United States.[2/] Further, the Federal government has for some time operated Wind Profilers using the 914-916 MHz band. The results of both Radian's and the Federal Governments's tests and operations sharing the 915 MHz and other bands with other users reveal that a 2 MHz co-secondary allocation in the 914-916 MHz band will allow commercial use and further development of Wind Profilers without objectionable interference to other allocated users.

I. *ALLOCATION AUTHORITY*

Section 7 of the Communications Act of 1934 provides that:

> It shall be the policy of the United States to encourage the provision of new technologies and services to the public. . . . The [Federal Communications] Commission shall determine whether any new technology or service proposed in a petition or application is in the public interest . . .

47 U.S.C. §157. Section 303(g) of the Communications Act further provides that the Commission shall:

> Study new uses for radio, provide for experimental uses of frequencies, and generally encourage the larger and more effective use of radio in the public interest.

47 U.S.C. §303(g). The Commission has, in the past, fulfilled this mandate by conducting rulemaking proceedings for the allocation of spectrum for new technologies. *See, e.g., In the Matter of Amendment of Parts 0,1,2, and 95 of the Commission's Rules to Provide Interactive Video and Data Services*, 7 FCC Rcd 1630 (1992). Because, as shown below,

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2/ *See* FCC File Nos. 1972-EX-PL-91, 1974-EX-PL-91, 1975-EX-PL-91, 1976-EX-PL-91, 1977-EX-PL-91, 1973-EX-PL-91, 1971-EX-PL-91, 1405-EX-PL-90, 2156-EX-PL-91, 2155-EX-PL-91; and 1906-EX-PL-91, specifying locations at Radian's corporate headquarters in Austin, Texas and at ten other sites in Wisconsin, Illinois, Indiana, Michigan, New York, Texas and California, many of which were utilized in the Lake Michigan Ozone Study.

the Wind Profiler is a new radio technology which will serve the public interest, the Commission should issue a Notice of Proposed Rulemaking for the amendment of Section 2.106 of its Rules to provide a 2 MHz secondary spectrum allocation in the 914-916 band for Wind Profilers.

II. *THE RADIAN SYSTEM*

Through a Cooperative Research and Development Agreement ("CRDA"), Radian, Sonoma Technology, Inc., and NOAA have developed the LAP™-3000 Lower Atmosphere Profiler, a portable, cost-effective wind profiler which can operate unattended and provide continuous real-time atmospheric data with high spacial resolution.

A. *Operation*

The basic components of a wind profiler include the transmitter, antenna array, receiver and processor.[3/] The LAP-3000 generates pulses of doppler-type radar and, based on the characteristics of the echo signal returned, measures wind speed, temperature and other environmental factors.[4/] An array of antenna patches transmits RF pulses in either three or five narrow, concentrated beams, with reduced side lobes. Typically, one beam is at zenith and the remaining beams are oblique, set at 15°-20° from zenith. The concentration of the beams permits maximum accuracy of resulting readings.[5/]

3/ Peterson, *WIND PROFILING -- The History, Principles, and Applications of Clear-Air Doppler Radar* (Vaisala Met, 1988) ("Peterson") at 19. Reproductions of all monographs and articles cited herein have been submitted herewith in an Appendix.

4/ Peterson at 4-12, B-1-B-2; Rick Palm, "Wind Profilers at 449 MHz," *QST*, March, 1992 ("Palm") at 20-21.

5/ Peterson 8-13, 19-20; Palm 21; Barth, "Wind Profiler Frequencies," *QST*, April 1992 ("Barth") at 22.

The return signal is picked up by the antenna and amplified by the receiver, which digitizes the return signal's phase and amplitude components and sends the data to the processor. The processor then tabulates the wind profile from the digitized data.[6/]

B. *The Many Uses of Wind Profilers*

Wind Profilers provide information which enhance safety of life and efficiency in many areas, several of which are briefly described below. Further, in each of these areas as well as others, the Wind Profiler provides a valuable research tool for future advances. The sampling of known uses described below demonstrates that allocation of the 914-916 MHz band for the use of Wind Profilers would serve the public interest.

Meteorological

Wind profilers operated in the 915 MHz band can be used to more quickly, economically and accurately predict dangerous weather phenomena, such as thunderstorms, tornadoes, and tropical cyclones, than can the current method of launching weather balloons (radiosondes).[7/] With an FCC spectrum allocation, Wind Profilers can become a common meteorological tool enabling a vast improvement in accurate commercial weather forecasting.

Aviation

Wind Profilers located in the vicinity of airports can serve an important safety function by detecting wind shear conditions, a serious air hazard. Helicopters, aircraft carriers, missile and satellite launches and the Space Shuttle program similarly stand to

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6/ Peterson 19-20.

7/ Peterson at B-2.

reap safety benefits from the continuous, high-resolution wind data that a state of the art 915 MHz Wind Profiler can provide.[8/]

Environmental

Wind Profilers can be used to study pollutants. Specifically, they can track dispersion, diffusion rates and trajectories of airborne substances such as acid rain.[9/] Seven out of eleven of Radian's current experimental licenses are in connection with the Lake Michigan Ozone Study. These systems were used to measure the wind flow and pollutant dispersion patterns in the vicinity of Lake Michigan. The data will be used to document the sources and transport of air pollutants and, thus, the polluting impact of individual states on their neighboring states.[10/]

Wind Profilers have also been used to assess the effect of power plant pollutants on visibility in the Grand Canyon, and to document the pollution transport patterns in California's San Joaquin Valley in order to develop pollutant control strategies.[11/]

In addition, data thus compiled ultimately can permit swift and effective responsive action to protect health and lives from accidentally released radioactive particles from a nuclear power plant, airborne chemical weapons, and similar phenomena.[12/]

8/ *Id.* at B-3 - B-4; Barth, *passim*; Palm at 20-21.

9/ Peterson at B-4 - B-5.

10/ Lindsey *et al.*, "Upper Air Meteorological Measurements for the Lake Michigan Ozone Study," (1992).

11/ Lindsay and Wolfe, "Use of A New Generation Boundary Layer Profiler to Investigate Meteorological Processes in Complex Terrain" (1991); Wilczak *et al.*, "Wind Profiler Observations within California's San Joaquin Valley," *Fifth Conference on Mesoscale Processes* (1992); Neff *et al.*, "The Use of 915 MHz Wind Profilers in Complex Terrain and Regional Air Quality Studies," *Seventh Joint Conference on Applications of Air Pollution Meteorology* (1991).

12/ Peterson at B-4 - B-5.

III. *The 914-916 MHz Allocation*

NOAA and others have studied a number of potential spectrum allocations for Wind Profilers. The viable range of frequencies for Wind Profilers in the U.S. is 50 MHz - 1200 MHz.[13] The lower frequencies can be transmitted farther in the atmosphere but with less vertical resolution than the higher frequencies. Thus, the lower frequencies are most useful for readings from higher altitudes[14] and the higher frequencies are most effective for high-resolution lower atmosphere profilers such as Radian's.[15]

A. *Experimental Use of Other Frequencies*

The National Telecommunications and Information Administration ("NTIA") studied the operation of Wind Profilers in the 216-225 MHz, 400.15 -406 MHz, and 420-450 MHz bands.[16] The 216-225 MHz band for Wind Profilers will in some locations depend upon the impact of operations on adjacent TV broadcast operations and other users, including the fixed service, land mobile, aeronautical mobile and maritime mobile services, and also has a probability of interference with one major Department of Defense system.[17] Experimental use of the 400.15 - 406 MHz band created harmful interference with the safety-of-life SARSAT (Search and Rescue Satellite Aided Tracking) system and its Russian equivalent, COSPAS, which researchers' subsequent efforts could not cure and which could only be expected to increase with wide-scale commercial use.[18] Finally,

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13/ Barth at 22.

14/ NOAA has determined that 200-500 MHz is the optimal range for upper-atmosphere Wind Profilers. Barth at 22.

15/ NOAA; Barth at 22-23; Palm at 21.

16/ Memorandum, dated December 11, 1991, from Richard D. Parlow, Associate Administrator, Office of Spectrum Management, National Telecommunications and Information Administration, to Executive Secretary, IRAC ("Wind Profiler Memo"), *passim*.

17/ Wind Profiler Memo at 1 - 3; Barth at 23.

18/ Wind Profiler Memo at 1-2; Barth at 23; Palm at 22.

while government studies concluded that 420-450 MHz is the most suitable lower-frequency band for Wind Profilers, it is unsuitable for lower-atmosphere profilers and many Department of Defense users object to its use.19/ Recent tests by NOAA in Colorado indicate substantial potential for interference with Amateur Radio repeaters in this frequency range.20/

B. *Use of 914 - 916 MHz for Wind Profilers*

The 915 MHz band is currently allocated on a primary basis for Industrial, Scientific, and Medical ("ISM") equipment, governed by Part 18 of the Commission's Rules, and on a secondary basis to the Amateur Radio Service.

Experimental use of this frequency for Wind Profiler Radar was begun in 1979, and has continued nationwide at a total of 39 sites, eleven of which are experimentally licensed to Radian. To date, no instances of harmful interference have been reported.21/ For the reasons described below, with an FCC spectrum allocation, Wind Profilers can be expected to produce little or no adverse impact on the users sharing the 915 MHz band.22/

19/ Wind Profiler Memo at 2.

20/ This is based upon communications between Radian and R.G. Straugh of NOAA/WPL, June 1992.

21/ *See* footnote 2, *supra*; *Request for IRAC/Spectrum Planning Subcommittee Review for Stage 3 Frequency Assignment for Telecommunication Systems Intended to Provide Radiolocation Service for Wind and Temperature Profiling in the 890-942 MHz Band for the Federal Government*, dated October 22, 1991, at 2.

22/ Radian has been advised that the Commission is considering allowing Automatic Vehicle Monitoring Systems ("AVMS") to operate throughout the 912-928 MHz band, and has requested that the Interdepartmental Radio Advisory Committee ("IRAC") permit the same. Radian is investigating the extent to which AVMS would interfere with wind profilers. AVMS is presently authorized to operate in the 902-912 and 918-928 MHz bands, which presents no interference issues.

1. *ISM Equipment*

Wind Profilers are unlikely to interfere with ISM equipment, because ISM equipment, by definition, generates and uses RF energy "locally," i.e., usually within the emitting equipment itself (e.g., microwave ovens) or within a few feet of the transmission origin. In contrast, Wind profilers are designed to radiate in a narrow, *vertical* beam, with low level side lobe emissions, and are best located in isolated, unpopulated areas, where few ISM devices can be expected.[23/] On those rare occasions when interference does result, adjustments to antenna orientation and perimeter fencing will frequently eliminate the problem.[24/]

2. *Amateur Service*

Similarly, the radiation characteristics inherent in Wind Profiler operations and the generally remote locations of those operations leads Radian to believe that a co-secondary spectrum allocation of 914 - 916 MHz to Wind Profilers will cause little interference to amateur operations.[25/]

IV. *LICENSING REQUIREMENTS*

Because Wind Profilers are a form of radiolocation, and are used for substantially similar (albeit broader) purposes, licensing eligibility for Wind Profiler Radar station operators using the 914-916 MHz band should be substantially the same as those set forth in Section 90.103 of the Commission's Rules for operators of stations in the radiolocation service, i.e. engagement in commercial, industrial, scientific, educational or local

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23/ *Id.* Further, as a secondary user, Wind Profilers would be required to cure all interference with ISM devices or cease operations at the interfering location. 47 C.F.R. Sec. 2.105(c)(3).

24/ Daniel C. Law, "Wind Profilers: Applications and Characteristics," *QST*, June 1992, at 49-50.

25/ *Id.* Radian is willing to work closely with amateur groups to ensure that any instances of interference are minimized.

government activity; furnishing of Wind Profiling services to others or to an affiliated entity regularly engaged in commercial, industrial, scientific, educational or local government activity.

Conclusion

Based on the foregoing, Radian Corporation respectfully requests that the Commission (1) initiate a rulemaking proceeding proposing the allocation of 2 MHz in the 914-916 MHz band for the co-secondary use of Wind Profiler Radars as described herein; and (2) allocate the requisite 2 MHz in the 914-916 band for Wind Profiler Radar use on a secondary basis.

Respectfully submitted,

RADIAN CORPORATION

By: ______________________
Lee W. Shubert
James E. Dunstan
Susan H. Rosenau

Its Attorneys

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Dated: August 13, 1992

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<u>APPENDIX OF REFERENCES</u>

TABLE OF CONTENTS

APPENDIX A

WIND PROFILING
The History, Principles, and Applications of Clear-Air Doppler Radar

By:

Vern L. Peterson
Vaisala Met System,
Tycho Technology, Inc.

VAISALA MET SYSTEMS

WIND PROFILING

The History, Principles, and Applications of Clear-Air Doppler Radar

TYCHO TECHNOLOGY, INC.

VAISALA MET SYSTEMS

WIND PROFILING

The History, Principles, and Applications of Clear-Air Doppler Radar

Vern L. Peterson

TYCHO TECHNOLOGY, INC.
A VAISALA SUBSIDIARY

I would like to acknowledge the contributions of the many staff members of Tycho Technology, Inc. and Vaisala Oy who provided editorial and production support for this booklet. In particular, I would like to thank Ilkka Ikonen, who wrote Appendix C.

--VLP

Third printing, January 1990

TYCHO TECHNOLOGY, INC.

research interests, or as operational systems helping to bring practical benefits to users in a variety of applications.

Tycho Technology, Inc.*, a subsidiary of Vaisala Oy, Helsinki, Finland, has played an important role in the growth of wind profilers. We are proud of this role and feel privileged to bring this technology to the world community.

The purpose of this document is to acquaint the reader with the history, physical principles, signal processing methods, and hardware used in wind profiling and to discuss some of its applications.

* Tycho Technology, Inc. of Boulder, Colorado, USA was named after the Danish astronomer Tycho Brahe (1546–1601), whose weather observations from 1582–1598 constituted one of the earliest systematic meteorological records.

1. INTRODUCTION AND OVERVIEW

Our knowledge of the state of the Earth's atmosphere is highly dependent upon the instruments we use for measuring it. The parameters of primary interest are temperature, pressure, humidity, precipitation, and wind. Meteorological instruments have been refined over the years and routine surface measurements of these parameters have been made throughout the world since the nineteenth century. However, it was not until this century that we began to get a systematic look at the space and time variability of the atmosphere as a function of height above the ground. A significant advance in this area was made some 50 years ago with the development of the radiosonde, a device carried aloft by a balloon to measure temperature, pressure, and humidity and transmit these data back to a ground station. By tracking the motion of the balloon, the winds aloft could also be determined. The radiosonde has become the standard instrument for upper-air measurements and today approximately 800 stations around the world release them on a regular basis - usually every 12 hours.

Although measurements every 12 hours at these locations may be enough to define the large-scale (synoptic) weather patterns, this is not sufficient to define the significant smaller-scale weather events. Advances in our understanding of the weather are dependent upon obtaining measurements with a higher resolution in both time and space. Many other applications also require more frequent and more closely-spaced upper-air measurements. Even though radiosondes are inexpensive, the relatively high cost of maintaining balloon launching and tracking facilities has precluded more extensive use.

Development of remote sensing technology offers a solution to this problem. In particular, it is now possible to measure vertical profiles of the wind on a nearly continuous basis (at remote, unmanned sites, if needed), with an accuracy better than that normally obtained with most balloons, and more economically. These revolutionary instruments are known as wind profiling radars (or wind profilers). They are suitable as research tools in assisting scientists in a wide spectrum of

2. WIND PROFILING: HISTORY AND PRINCIPLES OF OPERATION

The measurement of the wind above the earth's surface can be accomplished in many ways, all of which involve measuring the motion of some sort of "tracer". The most common tracer used is a balloon. Others include smoke trails, radar chaff, and water droplets. The tracers discussed in this document are turbulent eddies in the air and the measurement tool is the new wind profiler. A brief discussion of other wind measuring methods is found in Appendix C.

2.1 CONVENTIONAL WEATHER RADARS

Radar (RAdio Detecting And Ranging) technology has undergone almost continuous refinement since it was first developed early in this century. In its simplest form, a radar transmits a pulse of energy in a selected direction and then "listens" for an echo (Figure 1). From the time delay between transmission and reception of the echo, the distance to the target can be computed. Although the initial applications of radar were for detecting solid objects, such as airplanes, it was soon discovered that radar can also detect hydrometeors (rain, ice, snow, etc.) in the atmosphere, principally those large enough to precipitate. Remote detection of hydrometeors became the foundation for the science of radar meteorology.

The conventional weather radar (precipitation radar) consists of a radio transmitter and receiver, a rotating antenna, and a cathode ray tube (CRT) for displaying the received signals. This system can locate a storm and indicate its intensity from the amplitude of the returned signal (Figure 2). More modern weather radars are able to detect subtle changes in the frequency of the returned signal from which the radial velocity of the target hydrometeors can be determined using the Doppler principle. These systems are known as "Doppler" or "coherent" radars. If the hydrometeors are moving with the wind, the radial velocity of the wind relative to the radar site is also measured. For more details, see Battan (1973) or Doviak and Zrnic (1984).

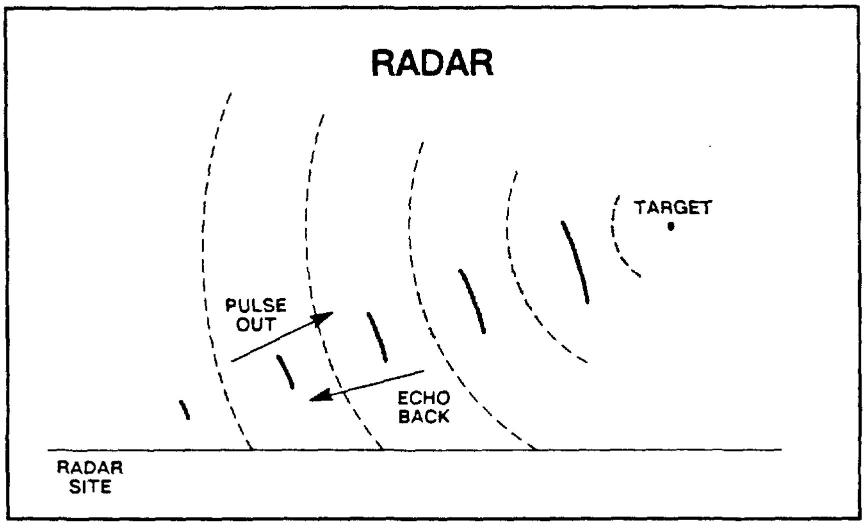

Figure 1 *The position of a target is determined by knowing the direction in which the beam is aimed and the time required to receive an echo after the pulse has been transmitted.*

These conventional weather radars, both Doppler and non-Doppler, are designed to detect reflections from objects *in* the air rather than the air itself. On occasion, echoes were noted that did not correspond to any visible object. Some of these were found to be reflections from swarms of insects or birds. Others were shown to be from the air itself. These echoes that originate in "clear air" are the foundation of wind profiling.

2.2 BRIEF HISTORY OF WIND PROFILING

Conventional Doppler weather radars are designed to detect hydrometeors. They are not sensitive enough (because of their short wavelengths) to detect the clear air, except under unusual conditions. On occasion, isolated turbulent layers can be seen with these radars. A few wind measurements in these layers were made during the same period that wind profilers were being developed. See Atlas, *et al.* (1969),

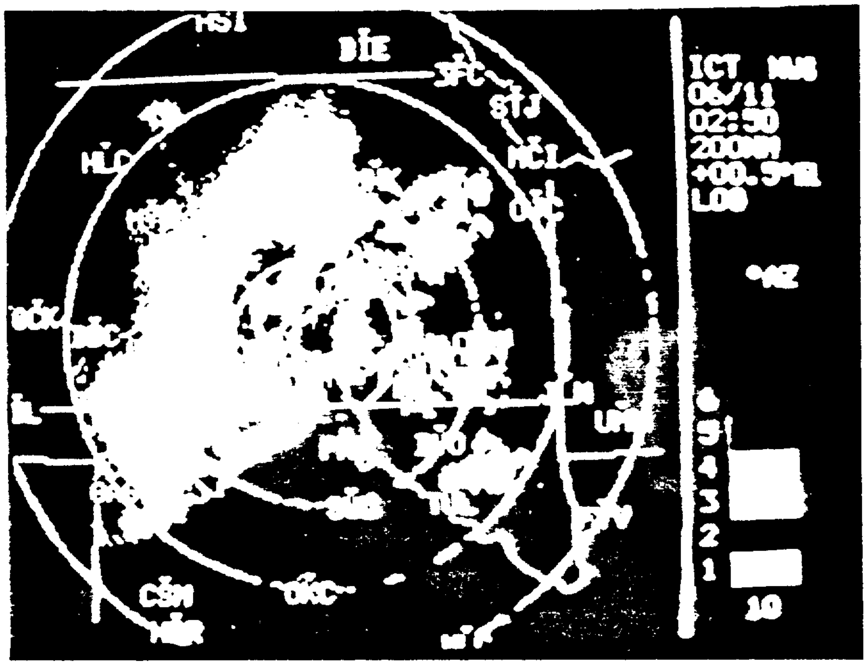

Figure 2 Sample of data from conventional weather radar.

Dobson (1970), Browning, *et al.* (1972), Birkemeier, *et al.* (1973) and Gossard and Strauch (1983) for some of the earliest wind measurements in the clear air using conventional Doppler weather radars.

The development of the modern wind profiler is an outgrowth of research work done with radars designed to probe the ionosphere, where longer wavelengths and extreme sensitivity was required. During the latter half of the 1960s, techniques were developed to measure radial velocities of the ions and electrons in the ionosphere, using the Doppler principle. These techniques were later used to examine the atmosphere below the ionosphere (the troposphere, stratosphere, and mesosphere). The first wind-soundings (vertical profiles of winds) of the clear stratosphere were made by ionospheric physicists using an ionospheric research radar at Jicamarca, Peru. These results were reported by Woodman and Guillen (1974).

The success of Woodman and Guillen in obtaining strong continuous echoes between 10 and 35 km altitude inspired the use of other ionospheric radars to probe the troposphere and stratosphere. These included the Chatanika, Alaska radar (Balsley and Farley, 1976) and the Arecibo, Puerto Rico radar (Farley, *et al.*, 1979). New Doppler radars designed specifically to exploit these findings were constructed. These included: the Sunset, Colorado (Green, *et al.*, 1975) and Platteville, Colorado (Ecklund, *et al.*, 1979) systems in the continental U.S., the SOUSY radar in the Federal Republic of Germany (Czechowsky, *et al.*, 1976), a small radar at Poker Flat, Alaska (Ecklund, *et al.*, 1977), and the large MST (Mesosphere, Stratosphere, Troposphere) radar at Poker Flat (Balsley, *et al.*, 1979). Both the Platteville and the Poker Flat MST systems were designed to provide continuous, unattended observations. These initial systems were followed by research systems in Australia, Japan, and France. One early project (1978) of Tycho Technology, Inc. was the Poker Flat MST radar, in which Tycho provided the 12,288 element, 50 MHz coaxial-collinear antenna system and sixty-four 50 kW transmitters.

The real drive to make wind profilers practical for routine meteorological application came from the Wave Propagation Laboratory of the National Oceanic and Atmospheric Administration in the U.S. during the early 1980s. The Colorado wind profiling network of one UHF and four VHF radars is described by Strauch, *et al.* (1984). This network of systems provided important insight into the optimal design details for an operational network. Tycho built much of the equipment that went into this network.

2.3 BASIC PRINCIPLES OF WIND PROFILING

In this section, the basic principles behind wind profiling are discussed. Mathematical details are given in Appendix A.

Wind profiling radars depend upon the scattering of electromagnetic energy by minor irregularities in the index of refraction of the air. The index of refraction is a measure of the speed at which electromagnetic waves propagate through a medium. For wind profiling, this medium is the atmosphere. A spatial variation in this index encountered by a propagating electromagnetic wave (radio wave) causes a minute amount of the energy to be scattered (or dispersed) in all directions. Most of the energy incident on the refractive irregularity propagates through it without being scattered.

In the atmosphere, minor irregularities in the index of refraction exist over a wide range of sizes. In the lower portion of the atmosphere (troposphere and stratosphere), the index of refraction depends primarily upon the temperature, pressure, and humidity of the air. The atmosphere is in a constant state of agitation, which produces irregular, small–scale variations in temperature and moisture over relatively short distances. The wind, as it varies in direction or speed, produces turbulent eddies (small, whirling currents of air). Likewise, irregular heating of the ground by the sun, associated with different surface conditions, provides another mechanism for the formation of eddies. Turbulent eddies are created over a spectrum of sizes ranging from many tens of meters down to centimeters, or even millimeters. Current theory holds that an eddy, once created, is unstable and tends to break up into smaller eddies, which in turn break up into still smaller eddies, and so on. At the smallest sizes, the cascading of energy into smaller eddies ceases and is replaced by dissipation of the energy by viscous heating.

These eddies produce the small and irregular variations in the index of refraction of the air that initiate scattering. As mentioned above, radio frequency electromagnetic pulses propagating through the air lose part of their energy to scattering from these refractive irregularities. A small portion of this scattered energy is returned to the radar site, where it can be received and analyzed. Backscattering (scattering of energy toward its point of origination) occurs preferentially from irregularities of a size about one–half the wavelength of the probing radio wave.